as practicable from parts of the interchangeable standard bushings. Thus an additional top porcelain with clamping rings attached, such as used on the standard apparatus bushing, will serve as a spare part not only for the apparatus bushing but for either end of the roof and wall bushings.

The center tube of the roof and wall bushings is utilized as the conductor with a terminal coupling at either end. The outside end of the wall bushing is closed with a metal expansion member, to allow for the different expansion of the metal tube and the porcelain shells. A connection is provided on the wall bushing from the grounded metal sleeve to an external oil reservoir, with a sight gauge in the pipe for observing the oil level.

Roof or wall thimbles are supplied when desired. In the case of the roof thimble, the opening is made large enough to pass the supporting flange of the bushing, and an intermediate adapter is provided between the bushing and the thimble. This allows the bushing to be hoisted through the roof thimble from within the building, which is frequently more convenient than raising it to the roof from the outside. Both the bushing adapter and the roof and wall thimbles are laid out to receive standard blank pipe flanges for closing the openings during construction or previous to installation of the bushings.

Packing and Shipping

For domestic shipment, these bushings are usually packed upright in crates as illustrated in Fig. 20. Compound-filled bushings are shipped filled. Oil-filled bushings are usually shipped empty with the oil in separate containers, although they can be shipped filled when desirable.

When horizontal shipment to domestic customers is necessary or desirable, the bushings are packed singly in a double excelsior lined box as shown in Fig. 19. For foreign shipment, a similar form of horizontal packing is employed, except that a heavier construction is used to meet the more severe requirements of foreign shipments. This is shown in Fig. 21.

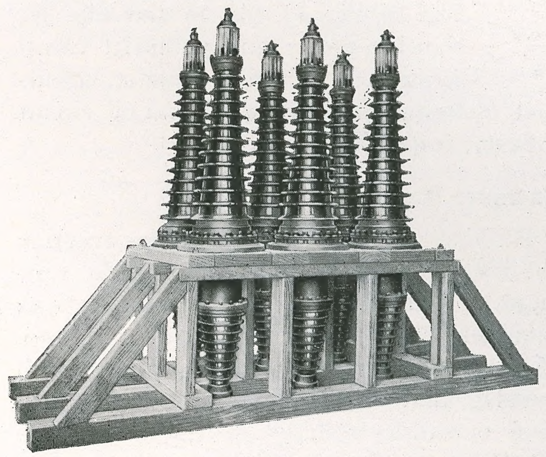


Fig. 20. METHOD OF PACKING FILLED TYPE BUSHINGS FOR DOMESTIC SHIPMENT, UPRIGHT IN CRATES

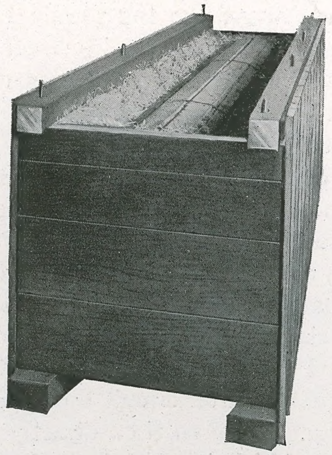


Fig. 21. HORIZONTAL PACKING OF FILLED BUSHINGS FOR SHIPMENT TO FOREIGN COUNTRIES

General Office: Schenectady, N.Y.
ADDRESS NEAREST OFFICE

Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va.
Charlotte, N. C.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Columbus, Ohio
*Dallas, Tex.
Dayton, Ohio
Denver, Colo.
Des Moines, Iowa
Detroit, Mich.
Duluth, Minn.
Elmira, N. Y.
Erie, Pa.
*El Paso, Tex.
Fort Wayne, Ind.
Grand Rapids, Mich.
Hartford, Conn.
*Houston, Tex.
Indianapolis, Ind.
Jacksonville, Fla.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Little Rock, Ark.
Los Angeles, Cal.
Louisville, Ky.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Niagara Falls, N. Y.
*Oklahoma City, Okla.
Omaha, Neb.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
Providence, R. I.
Richmond, Va.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Schenectady, N. Y.
Seattle, Wash.
Spokane, Wash.
Springfield, Mass.
Syracuse, N. Y.
Toledo, Ohio
Washington, D. C.
Worcester, Mass.
Youngstown, Ohio

*Southwest General Electric Company

INTERNATIONAL GENERAL ELECTRIC CO., INC.
120 Broadway, New York City, and Schenectady, N. Y.
REPRESENTATIVES AND AGENTS IN ALL COUNTRIES

General Electric Company

Schenectady, N.Y.

May, 1920 *Bulletin No. 49401*

INTERCHANGEABLE HIGH VOLTAGE BUSHINGS

TYPES OFI AND CFI

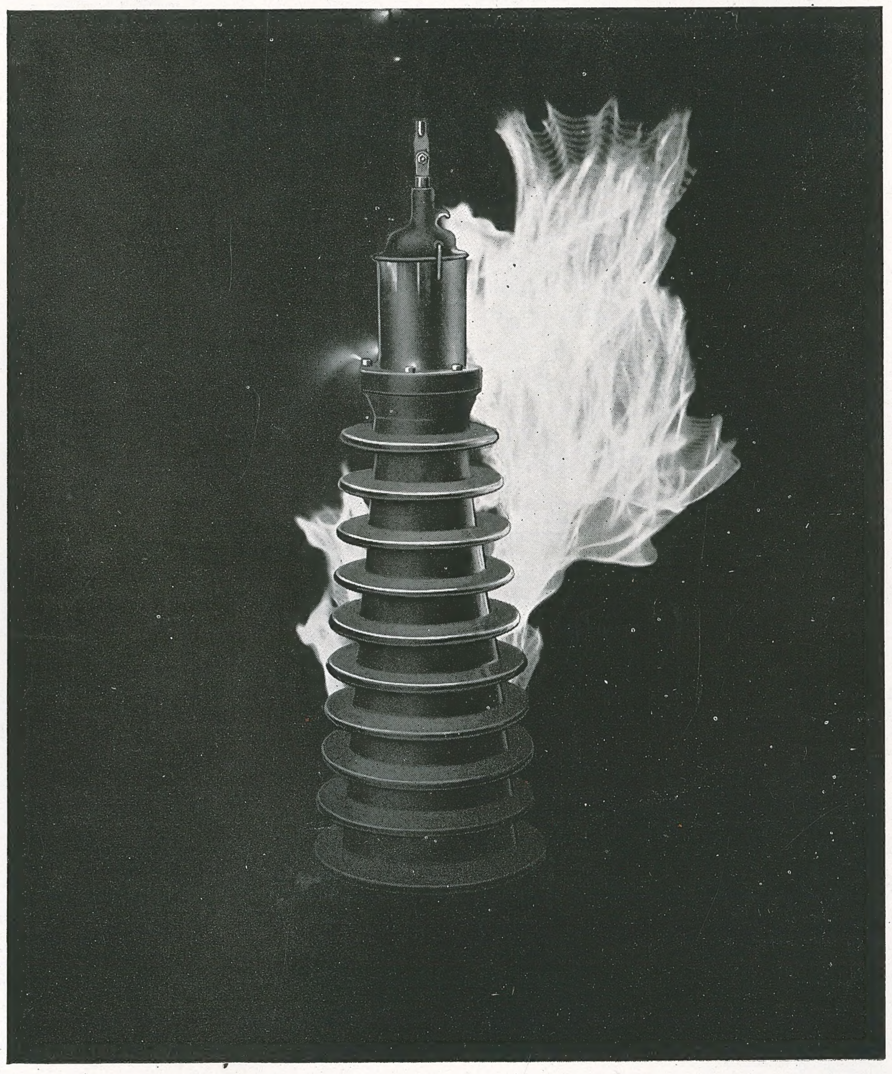


Fig. 1. DRY FLASHOVER OF F3 BUSHING AT 395,000 VOLTS

NOTE.—Data subject to change without notice.
Class 215.

INTERCHANGEABLE HIGH VOLTAGE BUSHINGS

TYPES OFI AND CFI

With the increase in voltage and size of power transmission systems, the interconnection of such systems, and the demand for greater reliability and absence of service interruption, the General Electric Company has given increasing attention to the perfection and standardization of the high voltage bushings or terminals of the various classes of apparatus connected to these high-voltage circuits.

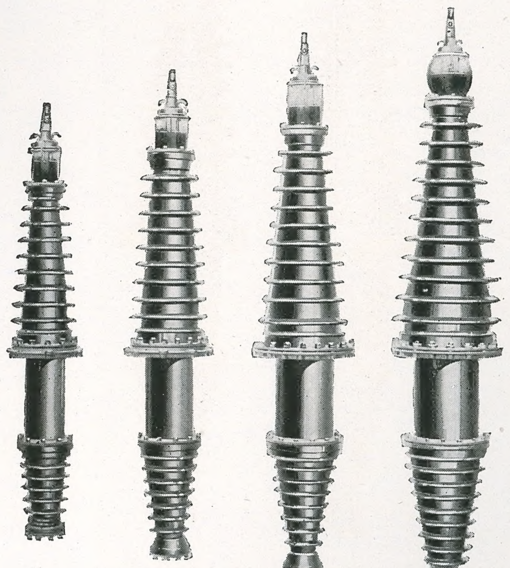


Fig. 2. FILLED TYPE FLANGE CLAMPED PORCELAIN HIGH VOLTAGE BUSHINGS FOR TRANSFORMERS, OIL CIRCUIT BREAKERS AND LIGHTNING ARRESTERS. RANGE OF OPERATING VOLTAGES, 73,001 TO 155,000 VOLTS

The General Electric Company's standard types of bushings are divided into two groups: those for operating voltages not exceeding 73,000 volts, which are of the "solid" type, and those for voltages above 73,000, which are of the "filled" type. Some of the more important features of design and performance of the "filled type" bushings are dealt with in this bulletin.

A line of filled type bushings, which is partly illustrated in Figs. 2 and 3, has been standardized for operating voltages between 73,000 and 220,000 volts. The keynote in the design of these bushings, both electrical and mechanical, has been *reliability;* in their application, it has been *interchangeability.* As illustrated in Fig. 4, these bushings are

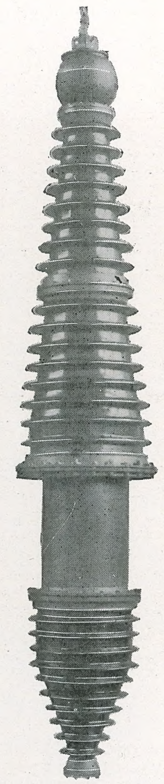


Fig. 3. FILLED TYPE, FLANGE CLAMPED PORCELAIN HIGH VOLTAGE BUSHING FOR TRANSFORMERS, OIL CIRCUIT BREAKERS AND LIGHTNING ARRESTERS. MAXIMUM OPERATING VOLTAGE, 220,000 VOLTS

interchangeable between all the standard classes of high voltage apparatus, so that a given bushing, when equipped with the proper detachable terminal accessories, may be assembled with a power transformer, an oil circuit breaker, a lightning arrester, a potential metering transformer or a current metering transformer, or may be transferred from one to the other. They are supplied in designs adapted to high and low altitude installations, as shown in Fig. 5, according to the location of the system, and are uniformly suitable for outdoor service.

Rating

The voltage rating of a bushing is related to, and should not be less than, the highest normal operating voltage of the circuit to which it is connected. As far as the bushings are concerned, this normal rating should apply to all parts of the circuit, including both the generating and receiving ends of the line. This is desirable because the over-voltage stresses to which the bushings, as well as other insulation, are subjected, may be as great at the receiving end of the line as at the generating end, although, under normal operating conditions, the voltage at the receiving end is usually lower.

As a general rule, no distinction is made between systems which are Y-connected and those which are delta-connected, in so far as the choice of bushings is concerned. This is the regular practice also in the case of high voltage lightning arresters. No system may be considered grounded, from the standpoint of the bushings, unless dead grounded at both ends of the line, at present a rather unusual condition. Even such grounds may be disconnected from the system by opening the high voltage oil circuit breakers, which would leave the line bushings on the circuit breakers connected to ungrounded lines. Until experience has shown conclusively that so-called grounded systems present less severe operating conditions for the bushings, it appears to be good engineering practice to treat all systems alike, disregarding their connections.

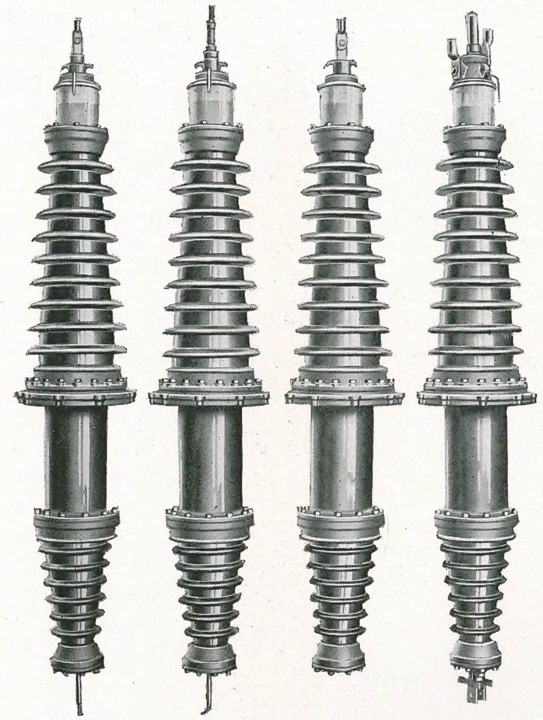


Fig. 4. FILLED TYPE HIGH VOLTAGE BUSHINGS CLASS F2 400 A. EQUIPPED WITH TERMINAL ACCESSORIES (DETACHABLE) FOR THE CLASS OF SERVICE INDICATED. LEFT TO RIGHT: CONSTANT POTENTIAL TRANSFORMER, LIGHTNING ARRESTER, OIL CIRCUIT BREAKER AND CURRENT METERING TRANSFORMER

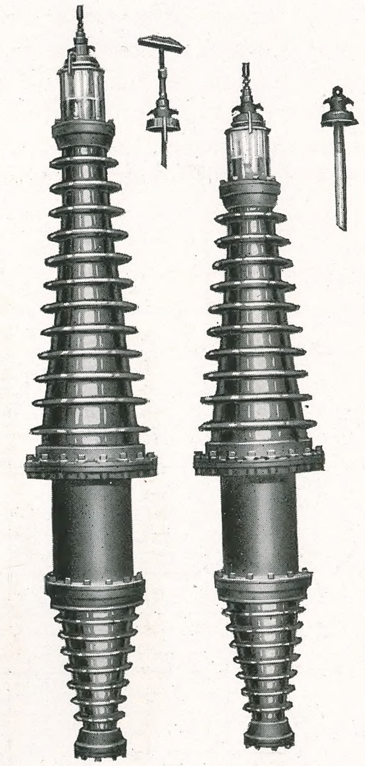


Fig. 5. FILLED TYPE HIGH VOLTAGE BUSHINGS FOR HIGH AND LOW ALTITUDE SERVICE. TRANSFORMER CONTACTS ON BUSHINGS, LIGHTNING ARRESTER TRANSFER CONTACT IN CENTER AND OIL CIRCUIT BREAKER CONTACT AT RIGHT

The coefficient of safety is based on the A. I. E. E. specifications for the test voltage of high voltage apparatus. Taking as a basis of reference the highest test specifications, namely, two and one quarter times the normal line voltage, plus 2000 volts, as in the case of oil circuit breakers, it has been found by careful review of past experience that a factor of safety in the bushings represented by a ratio of 7/10 to 9/10 of this test specification, has resulted in occasional flashover of the bushings in service. Ratios greater than 1 have always given successful operation. The test specification of the A. I. E. E., therefore, is considered safe and sufficient for the bushings, as well as for the completed apparatus. These "filled type" bushings are designed to withstand a test, with or apart from the apparatus with which they are operated, equal to the test specified in the Standardization Rules of the Institute.

The effect of altitude on the flashover voltage of bushings is similar to its effect on other types of gaps, such as lightning arrester gaps and line insulators. Fig. 6 shows a curve representing the relative flashover voltages at different altitudes of bushings of the type shown in Fig. 2. On this curve it will be noticed that a reduction in flashover voltage of about 12½ per cent is the result of an increase in altitude from sea level to 4000 feet. Likewise, an altitude of 10,000 feet corresponds to a reduction of 27 per cent in the flashover voltage. Thus a bushing which has a flashover voltage of 375,000 volts at sea level, would flashover at about 330,000 volts at 4000 feet altitude, and at about 275,000 volts at 10,000 feet. This illustrates the necessity for taking into account the altitude of the installation. Since the maximum one-minute test voltage of the bushing is definitely related to the flashover voltage, it follows that the normal operating voltage is also definitely related to the flashover voltage, and consequently is affected by the altitude of the installation For instance, a

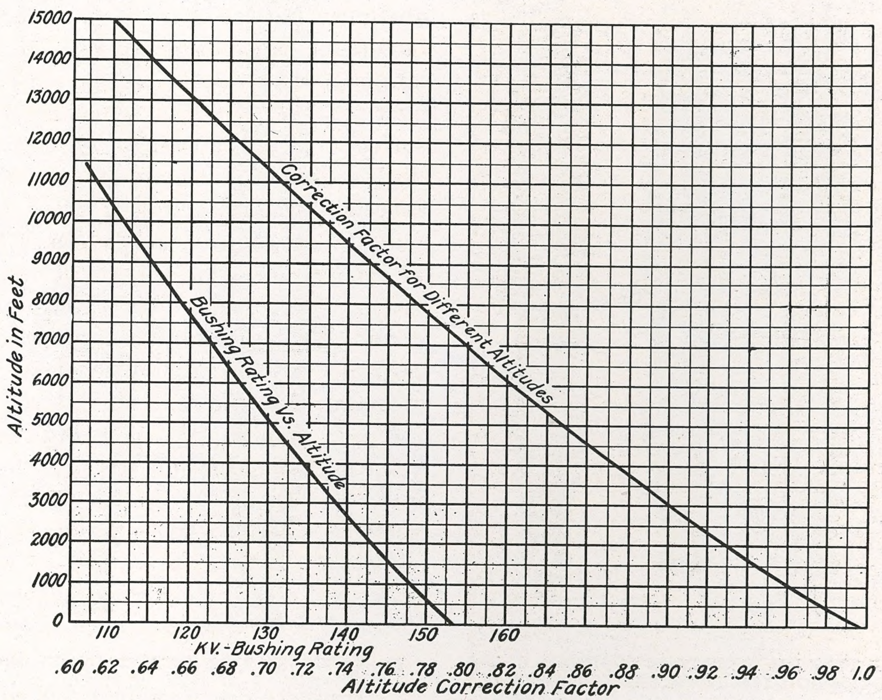


FIG. 6. CURVES SHOWING VARIATION IN BUSHING RATING WITH CHANGE IN ALTITUDE AND CORRECTION FACTOR FOR DIFFERENT ALTITUDES

bushing having a normal operating voltage rating of 154,000 volts at sea level, would be reduced in rating to 135,000 volts at 4000 feet, and to 112,000 volts at 10,000 feet.

This great effect of the altitude upon the rating of the bushing involves only the upper end of the bushing, whose insulating surface is exposed to the atmosphere. The puncture strength of the bushing is not affected by the altitude, nor the strength of the insulating surface of the lower end of the bushing, which is entirely submerged in the oil of the apparatus in which it is assembled. For this reason, installations at high altitudes, particularly those exceeding 4000 feet, are supplied with "high altitude" bushings, whose upper section has been lengthened to increase the striking distance, corresponding to the decrease in the dielectric strength of air at the high altitude. As illustrated in Fig. 5, the high altitude and low altitude bushings are exactly alike below the supporting flange.

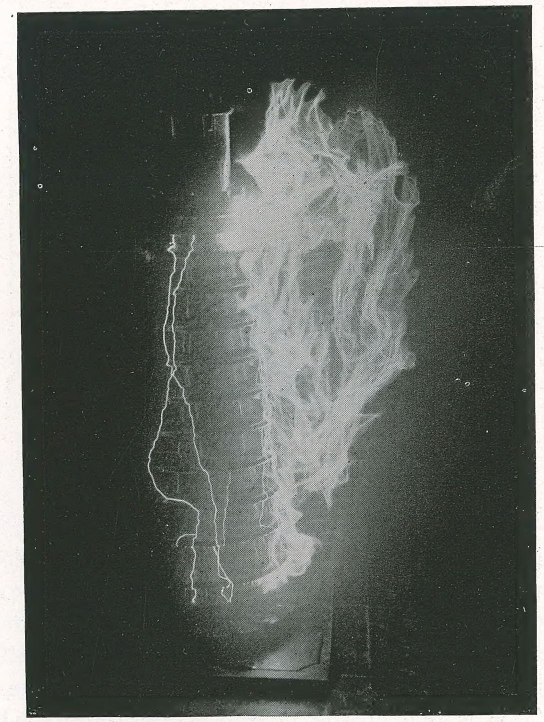


Fig. 7. WET FLASHOVER OF F3 BUSHING AT 305,000 VOLTS

Temperature also affects the relative air density, and consequently the arc-over voltage of the bushings. A difference of 1 deg. C. in temperature has the same effect on the relative air density, and therefore on the arc-over voltage, as a difference in altitude of 100 feet. Thus a difference of 40 deg. C. in temperature corresponds to a difference of 4000 feet in the altitude of installation. Such temperature conditions, however, exist at all altitudes and have to be considered in the factors of safety which apply to all installations. Other conditions also affect the flash-over voltage, such as the condition of the surface of the bushing, whether clean or dirty, different degrees of humidity and especially rainfall. All of these conditions, likewise, are present to a greater or less degree at all altitudes, and at all places of installation. Experience has shown that these conditions, inclusive of temperature, are properly provided for by the factor of safety represented in the A. I. E. E. test.

There should be some definite relation between the insulation strength of the bushing and that of the line to which it is connected. There exists, however, such a wide variation in the actual values of line insulation, not only on different systems, but at different points on the same system and at different periods of time after the erection of the line, that it is quite out of the question to establish any very definite relation between the bushing and the line insulation. Protective devices such as lightning arresters, on the other hand, offer a basis of comparison which can be utilized in the rating of the bushing.

Tests have shown that these standard bushings are very "slow" under high frequency impulses, which feature is highly desirable in order that high frequency disturbances shall be discharged over the protective gap, rather than over the bushings. On the other hand, in order to safeguard against low frequency disturbances, it is well to have the 60-cycle arc-over voltage of the bushing equal to at least twice the arc-over voltage of the protective spark gaps. This relation results from the theoretical value of the reflected wave. Considering a wave of potential just below the breakdown voltage of the protective spark gap, such a disturbance would not be discharged upon approaching the apparatus protected by the spark gap, and the wave would pass on to the transformer or end of the line, there to be reflected at theoretically double its initial value. Under such circumstances, the bushing should not flash over, but should withstand the double value of the wave, which would then be discharged by the spark gap.

All of these considerations have led to the assignment of an arbitrarily chosen symbol to each bushing in the standard line such as F1, F2, F3, etc., to the "low altitude" bushings, and F1A, F2A, F3A, etc., to the "high altitude" designs. These symbols serve to distinguish the different sizes of bushings in all particulars except current carrying capacity. The "flat" voltage rating has been superseded by the "voltage-altitude" rating, so that a given bushing may operate on systems of different voltage at different altitudes with the same factors of safety. This classification symbol also allows the bushing to be assigned to a system according to its operating conditions without violating any arbitrarily established voltage rating.

Performance

With bushings, as with other apparatus, and all the more so because upon the bushing depends the serviceability of the apparatus, reliability is the one characteristic which stands out above all others in the requirements of design. The successful bushing must be able to withstand all of the normal and abnormal conditions against which ingenuity can fortify it. Among the most important of these conditions is the ability of the bushing to protect itself against destruction from voltages in excess of its breakdown strength. Not only must the bushing be able to operate under all normal voltages, and such abnormal voltages as are within the range of its design, but it should be provided with a safety valve against still higher voltages which would endanger its puncture strength, and consequently its further usefulness. In other words, the bushing should have a puncture strength greater than its flashover strength, or conversely it should have a flashover voltage lower than

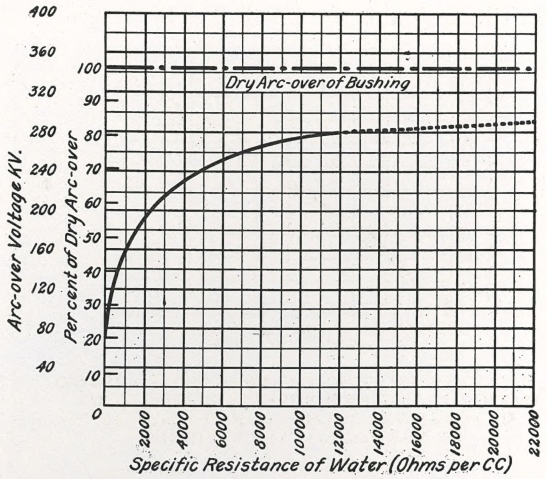


Fig. 8. CURVE SHOWING THE WET ARC-OVER VOLTAGE OF BUSHINGS FOR VARIOUS SPECIFIC RESISTANCES OF WATER AND THE PERCENTAGE OF THIS VOLTAGE TO DRY ARC-OVER VOLTAGE

its puncture voltage. That is, it should be able to withstand flashover without puncture, so that upon application of a voltage exceeding its flashover voltage, a flashover of the bushing will result, which will protect it against puncture. This is one of the characteristics embodied in the line of filled bushings here described. Figs. 1 and 7 illustrate this characteristic of flashover without puncture, both dry and wet. The bushing should be able to withstand such an experience an indefinite number of times.

The "speed" of the flashover of a bushing is also of special importance, just as is true of protective spark gaps, except that the bushing should have the opposite characteristic from the spark gap. It is essential that the spark gap, installed to protect the other apparatus, should discharge over-voltages promptly, with as little delay or "time-lag" as possible. Spark gaps differ greatly in this respect. Those which develop corona before flashover are subject to a comparatively long

time element, and are termed "slow." Those which do not develop corona before flashover are fast. Examples of these two types are the needle gap and the sphere gap respectively. The bushing, which is not a protective gap, should be so designed that it will have a considerable time lag, that is it will be slow to flashover. This characteristic has been included in the design of the filled type bushings.

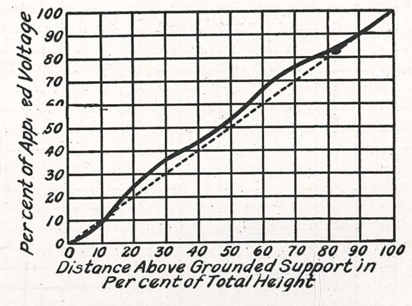
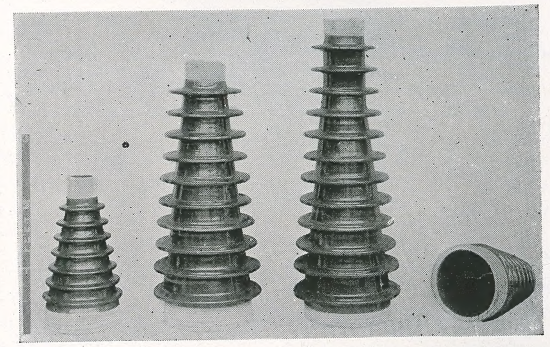


Fig. 9. CURVE SHOWING THE VERY CLOSE APPROXIMATION TO UNIFORM SURFACE DISTRIBUTION OF POTENTIAL OBTAINED IN THE DESIGN OF THE FILLED TYPE BUSHING

Reference has already been made to the A. I. E. E. test specifications of 2¼ times the normal line voltage plus 2000 volts. In order to apply this test for a period of one minute it is necessary to provide an instantaneous flashover value of about 10 per cent greater, or about 2½ times the normal line voltage. In the design of General Electric bushings, a flashover voltage equal to at least three times the normal line voltage is provided, and in the case of the lower voltage ratings, a still higher factor is used.

The wet flashover voltage under a rainfall of 0.2 in. per min., at an angle of 45 deg. varies from 70 per cent to 90 per cent of the dry value, depending on the size of the bushing, those of lower rating having the higher ratio. The value of the wet flashover voltage is affected greatly by the specific resistance of the water used in making the wet test. It was found in tests on a sample bushing, that a ratio of wet-to-dry flashover voltage of 80 per cent with water of 10,000 ohms per cubic cm., was reduced to a ratio of 55 per cent with water of 2000 ohms resistance. Fig. 8 illustrates the variation in wet arc-over of a bushing due to change in the specific resistance in the test water. As a rule rain water is higher in resistance than any tap water available for such tests. Distilled water represents an artificial condition which should not be employed in making wet tests on bushings and insulators. Naturally distilled water gives a higher wet test than tap water or even rain water, because of its higher resistance.



Bottom — Low Altitude Top — High Altitude Top — Bottom

Fig. 10. PORCELAIN PARTS FOR BUSHINGS

In order that the bushings shall not deteriorate under the voltage stress of normal service, the insulating surfaces should be entirely free from corona at all normal voltages, and preferably also at double normal voltage or those voltages which may appear repeatedly on the line. To accomplish this efficiently, a potential distribution is necessary which is uniform along the external insulating surface of the bushing. This is accomplished in the filled type bushings by features of design which give an essentially uniform surface distribution, such as is illustrated in Fig. 9. This uniform surface distribution means a uniform surface efficiency, so that the flashover voltage is proportional to the striking distance through the air from the top terminal to the grounded support. *The ratings of the bushings are therefore directly proportional to their linear dimensions.* The absence of corona on the insulating surface, even up to voltages approaching flashover, constitutes a protection of the surface from heating, which is always dangerous to the insulation. Corona is not suppressed, however, on the metal terminal parts at points not adjacent to the insulating surfaces, because the presence of corona previous to arc-over represents the dissipation of energy, and this in turn requires a time element which increases the time lag of the bushing.

Corona within the tank is entirely suppressed by the use of a grounded metal sleeve, which forms the central portion of the external shell of the bushing. The upper end of the sleeve is flanged to form a support upon the cover of the tank; the lower end extends below the surface of the oil. Thus all of the exposed surface of the bushing within the tank is at ground potential, and there can be no difference of potential along this surface, and consequently no corona or static discharge on the bushing in the air space above the oil. This is essential in order to prevent danger from the explosion of the gases which may collect in the air space between the oil and the cover.

These bushings are all designed to carry the rated current of the circuit at temperature rises which shall not injure the insulation nor exceed any established specifications. In the following paragraphs attention is called to the current carrying circuit through these bushings, which is different in the case of transformers and oil circuit breakers.

Construction

General Electric standard filled type bushings as illustrated in Fig. 2, consist of an external shell of porcelain and iron, through which there passes, from end to end, a metal tube surrounded by insulating barriers, spaced concentrically to form ducts filled with the oil, or insulating compound. The porcelain shells, one above the grounded metal sleeve, and the other below, are each in one piece as illustrated in Fig. 10, which shows a low altitude top, a high altitude top, and two duplicate bottom sections. The development and utilization of large single-piece porcelains for bushings represents a decided advance in the mechanical construction. It has eliminated the numerous joints between the narrow sections of earlier types of bushings, has permitted the flange clamping of the few remaining joints, and has effectively removed the danger of oil leakage.

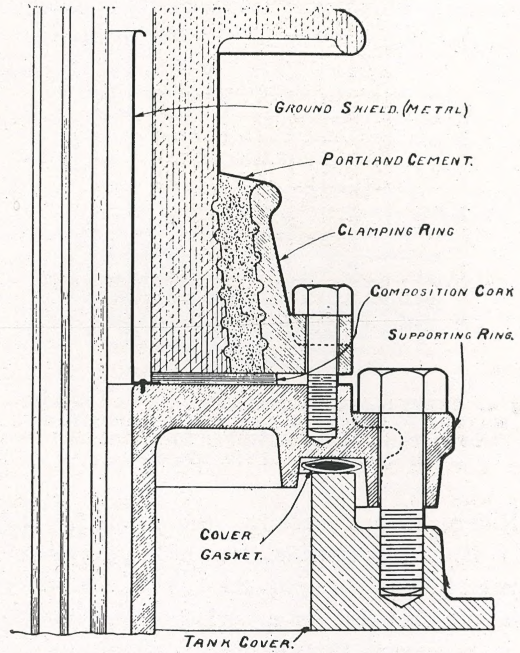


Fig. 11. DETAILS OF FLANGE CLAMPED JOINT OF FILLED TYPE HIGH VOLTAGE BUSHINGS

The value of oil as an insulating medium is everywhere recognized. This applies to bushings as well as other types of high voltage apparatus. Its high insulating strength, reaching extremely high values under impulse voltages, its ability to circulate freely and thus serve as a heat dissipating medium, and its fluid character which eliminates air pockets or voids in the insulation, all combine to make insulating oil the best possible dielectric for bushings for high voltages.

The method of attaching the porcelain shells to the adjacent metal fixtures is illustrated in Fig. 11. Around the grooved tapered end of each porcelain is a flanged metal clamping ring, secured to the porcelain with steam cured Portland cement. The end of the clamping ring is located

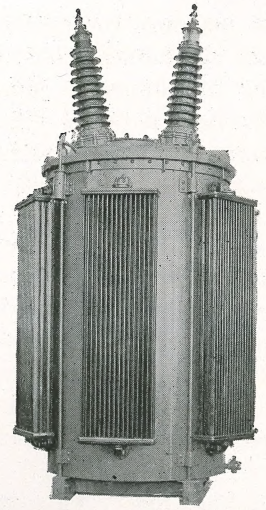


Fig. 12. 110,000-VOLT OUTDOOR TRANSFORMER EQUIPPED WITH CLASS F2 HIGH VOLTAGE BUSHINGS

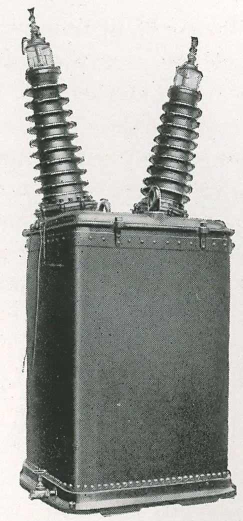


Fig. 13. 110,000-VOLT OUTDOOR POTENTIAL METERING TRANSFORMER WITH CLASS F2 BUSHINGS

flush with the carefully ground end of the porcelain which rests upon a varnish treated, composition cork gasket, between the porcelain and the machined surface of the adjacent metal part. By means of the many bolts through the flanged clamping ring, the gasket is tightly compressed between the porcelain and the adjacent metal. Thus a joint is made which is independent of any clamping pressure derived from the center tube through the bushing, and which depends for its tightness upon the local bolting of each clamping ring. The universal satisfaction which this construction has given is ample testimony to its reliability.

The center metal tube, extending lengthwise through the bushing from end to end, serves in the case of constant potential transformers and lightning arresters, as a conduit for the detachable cable conductor which connects the transformer winding or lightning arrester cone stack to the top terminal of the

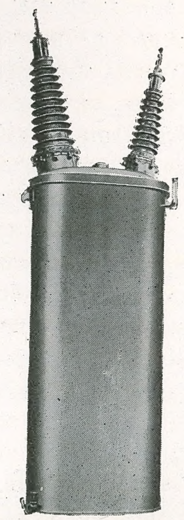


Fig. 14. ASSEMBLED TANK UNIT OF 115,000- 135,000-VOLT ALUMINUM LIGHTNING ARRESTER EQUIPPED WITH CLASS F3 LINE BUSHING AND CLASS F1 NEUTRAL BUSHING

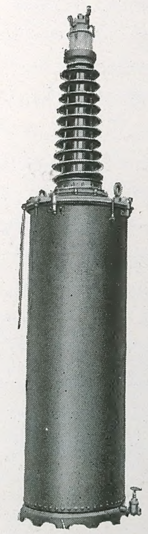


Fig. 15. 110,000-VOLT CURRENT METERING TRANSFORMER WITH CLASS F2-A BUSHING

bushing. In the case of oil circuit breakers, this center tube itself serves as the conductor, connections being made at the ends by means of suitable detachable contact parts. When used on a current metering transformer, the center tube of the bushing serves as one side of the double-conductor circuit, the second or return conductor being a concentric rod assembled inside of, and insulated from the center tube.

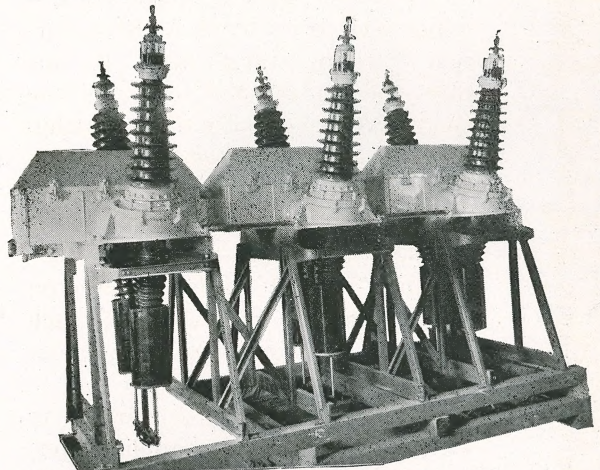


Fig. 16. TRIPLE POLE, SINGLE-THROW, SOLENOID OPERATED OIL CIRCUIT BREAKER EQUIPPED WITH CLASS F2 HIGH VOLTAGE BUSHINGS

The oil space inside of the bushing between the center tube and the external metal sleeve is divided into concentric ducts by means of insulating cylinders, which serve to direct the circulation of the oil lengthwise of the bushing and to increase the puncture strength between the center tube and sleeve. The top of the bushing is fitted with a glass gauge through which the level of the filler may be observed, and which acts as an expansion chamber to allow for the change in volume of the filler with change of temperature. In the bottom casting there is a drain plug for drawing off the oil when necessary.

Each bushing is provided with a name plate, on which there are indicated the nomenclature, classification, current capacity, serial number and specification number. A caution plate mounted beside the name plate indicates the kind of filler used with the bushing, i.e., whether oil or compound, and warns against an admixture of the two. The oil supplied with oil-filled bushings is generally of the same quality as that supplied with the apparatus with which the bushings are to be used. The compound in compound filled bushings is the General Electric Company's standard No. 239 which is a heavy rosin oil mixture, having the consistency of thick molasses.

Caution plates on high altitude bushings state that they should be used only at altitudes above 4000 feet. This restriction is imposed to safeguard the puncture structure of the bushing against the increased arc-over voltage which would result from the use of a high altitude bushing at low altitudes. With the accessories assembled on these bushings for current metering transformers, there is provided an additional name plate, indicating the combined current rating of bushing and accessories, which, because of the double-conductor feature, may differ from the main name plate rating of the bushing for other uses.

Interchangeability

A bushing of this type may be used on a power transformer, a potential metering transformer, a current metering transformer, an oil circuit breaker, or a lightning arrester. Detachable terminal accessories are used to adapt the bushing to any one of these classes of apparatus. The bushing may be interchanged among the different classes of apparatus by exchanging the terminal accessories. The name plate rating of course must be observed in considering interchangeability. Fig. 4 illustrates the four classes of service to which these bushings are adaptable.

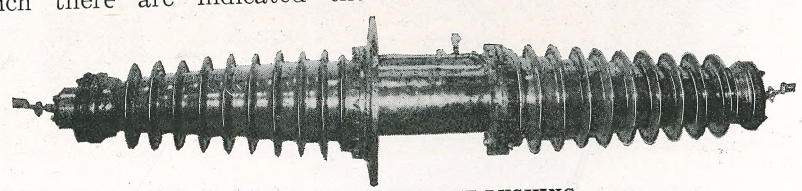


Fig. 17. WALL ENTRANCE BUSHING

The left-hand bushing in this figure is equipped with terminals for a constant potential transformer. The conductor is a detachable flexible cable, whose lower end extends to the terminal board or winding of the transformer, while the upper end terminates in a threaded stud, secured in the lifting hook casting at the top of the bushing. By loosening this connection at the top, the bushing may be removed from the transformer without effecting an entrance through the cover. It may be installed likewise by drawing the cable up through the centre tube while the bushing is being lowered upon the cover. This eliminates the necessity of removing or lowering the oil in the transformer, which is usually required by an internal connection to the bushing.

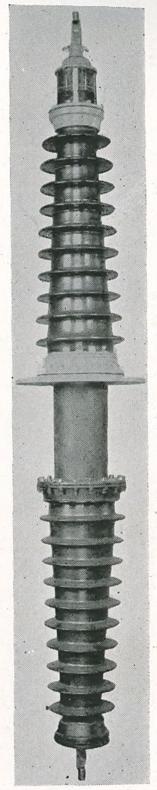


Fig. 18. ROOF ENTRANCE BUSHING

The second bushing in Fig. 4 is equipped with terminal parts for a high voltage lightning arrester. The contact shoe above the top terminal is a part of the transfer device, used for charging the third and fourth tanks of a four-tank arrester. In this case also, a flexible detachable conductor is used, passing from the connection on the cone stack up through the center tube to the top terminal. The neutral side of the arrester is usually fitted with a lower voltage bushing, which is not interchangeable with the line bushing, but usually of similar construction.

The third bushing in Fig. 4 shows the top terminal used with oil circuit breakers. This terminal makes connection directly to the center tube, which in this class of service is utilized as the conductor. The lower terminal or contact head which connects to the lower end of the center tube, is not shown in this illustration. This part varies with the design of the oil circuit breaker, and is different for breakers having different interrupting capacities.

The fourth bushing shows the terminal accessories for use with a current metering transformer. In this case, the center tube serves as one conductor, and a concentric rod within the tube and insulated from it provides a return circuit. The two connections at each end of the bushing are clearly distinguished in the illustration. Only one bushing is used on a single transformer, and two such bushings on a metering outfit, containing two transformers.

These five classes of apparatus to which these bushings are applied interchangeably are illustrated in Fig. 12, Fig. 13, Fig. 14, Fig. 15 and Fig. 16, showing power and potential transformers, a lightning arrester, a current metering transformer and an oil circuit breaker, respectively.

Entrance Bushings

Bushings of the same general construction as described for the interchangeable type have been developed with the modifications required for roof and wall entrance service. Fig. 17 shows a low altitude oil-filled wall bushing, and Fig. 18 shows a high altitude roof entrance bushing of the compound-filled type. These bushings are made as far

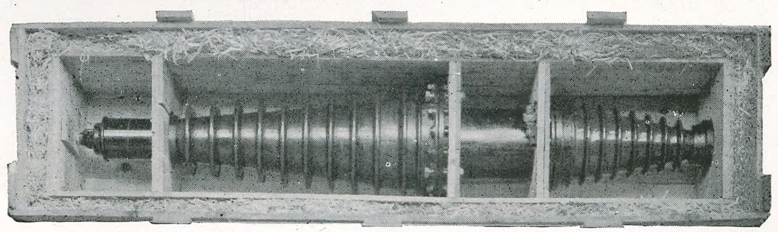


Fig. 19. HORIZONTAL PACKING OF SINGLE BUSHINGS FOR DOMESTIC SHIPMENT

as practicable from parts of the interchangeable standard bushings. Thus an additional top porcelain with clamping rings attached, such as used on the standard apparatus bushing, will serve as a spare part not only for the apparatus bushing but for either end of the roof and wall bushings.

The center tube of the roof and wall bushings is utilized as the conductor with a terminal coupling at either end. The outside end of the wall bushing is closed with a metal expansion member, to allow for the different expansion of the metal tube and the porcelain shells. A connection is provided on the wall bushing from the grounded metal sleeve to an external oil reservoir, with a sight gauge in the pipe for observing the oil level.

Roof or wall thimbles are supplied when desired. In the case of the roof thimble, the opening is made large enough to pass the supporting flange of the bushing, and an intermediate adapter is provided between the bushing and the thimble. This allows the bushing to be hoisted through the roof thimble from within the building, which is frequently more convenient than raising it to the roof from the outside. Both the bushing adapter and the roof and wall thimbles are laid out to receive standard blank pipe flanges for closing the openings during construction or previous to installation of the bushings.

Packing and Shipping

For domestic shipment, these bushings are usually packed upright in crates as illustrated in Fig. 20. Compound-filled bushings are shipped filled. Oil-filled bushings are usually shipped empty with the oil in separate containers, although they can be shipped filled when desirable.

When horizontal shipment to domestic customers is necessary or desirable, the bushings are packed singly in a double excelsior lined box as shown in Fig. 19. For foreign shipment, a similar form of horizontal packing is employed, except that a heavier construction is used to meet the more severe requirements of foreign shipments. This is shown in Fig. 21.

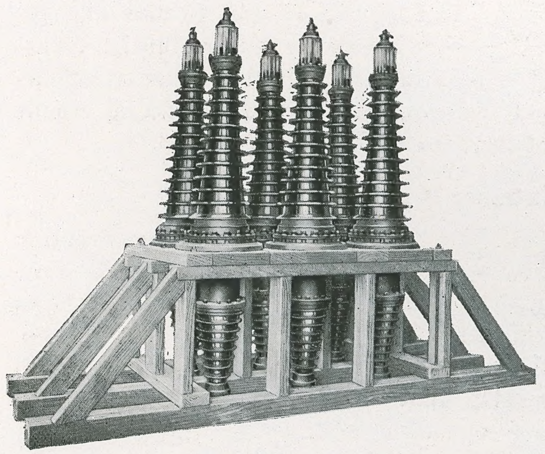


Fig. 20. METHOD OF PACKING FILLED TYPE BUSHINGS FOR DOMESTIC SHIPMENT, UPRIGHT IN CRATES

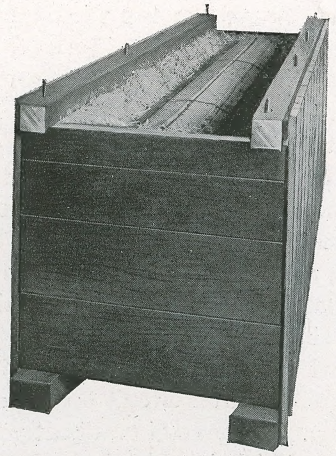


Fig. 21. HORIZONTAL PACKING OF FILLED BUSHINGS FOR SHIPMENT TO FOREIGN COUNTRIES

General Office: Schenectady, N.Y.

ADDRESS NEAREST OFFICE

Atlanta, Ga.
Baltimore, Md.
Birmingham, Ala.
Boston, Mass.
Buffalo, N. Y.
Butte, Mont.
Charleston, W. Va.
Charlotte, N. C.
Chattanooga, Tenn.
Chicago, Ill.
Cincinnati, Ohio
Cleveland, Ohio
Columbus, Ohio
*Dallas, Tex.
Dayton, Ohio
Denver, Colo.
Des Moines, Iowa
Detroit, Mich.
Duluth, Minn.
Elmira, N. Y.
Erie, Pa.
*El Paso, Tex.
Fort Wayne, Ind.
Grand Rapids, Mich.
Hartford, Conn.
*Houston, Tex.
Indianapolis, Ind.
Jacksonville, Fla.
Joplin, Mo.
Kansas City, Mo.
Knoxville, Tenn.
Little Rock, Ark.
Los Angeles, Cal.
Louisville, Ky.
Memphis, Tenn.
Milwaukee, Wis.
Minneapolis, Minn.
Nashville, Tenn.
New Haven, Conn.
New Orleans, La.
New York, N. Y.
Niagara Falls, N. Y.
*Oklahoma City, Okla.
Omaha, Neb.
Philadelphia, Pa.
Pittsburgh, Pa.
Portland, Ore.
Providence, R. I.
Richmond, Va.
Rochester, N. Y.
St. Louis, Mo.
Salt Lake City, Utah
San Francisco, Cal.
Schenectady, N. Y.
Seattle, Wash.
Spokane, Wash.
Springfield, Mass.
Syracuse, N. Y.
Toledo, Ohio
Washington, D. C.
Worcester, Mass.
Youngstown, Ohio

*Southwest General Electric Company

INTERNATIONAL GENERAL ELECTRIC CO., INC.
120 Broadway, New York City, and Schenectady, N. Y.
REPRESENTATIVES AND AGENTS IN ALL COUNTRIES

General Electric Company
Schenectady, N.Y.

May, 1920 | *Bulletin No. 49401*

INTERCHANGEABLE HIGH VOLTAGE BUSHINGS

TYPES OFI AND CFI

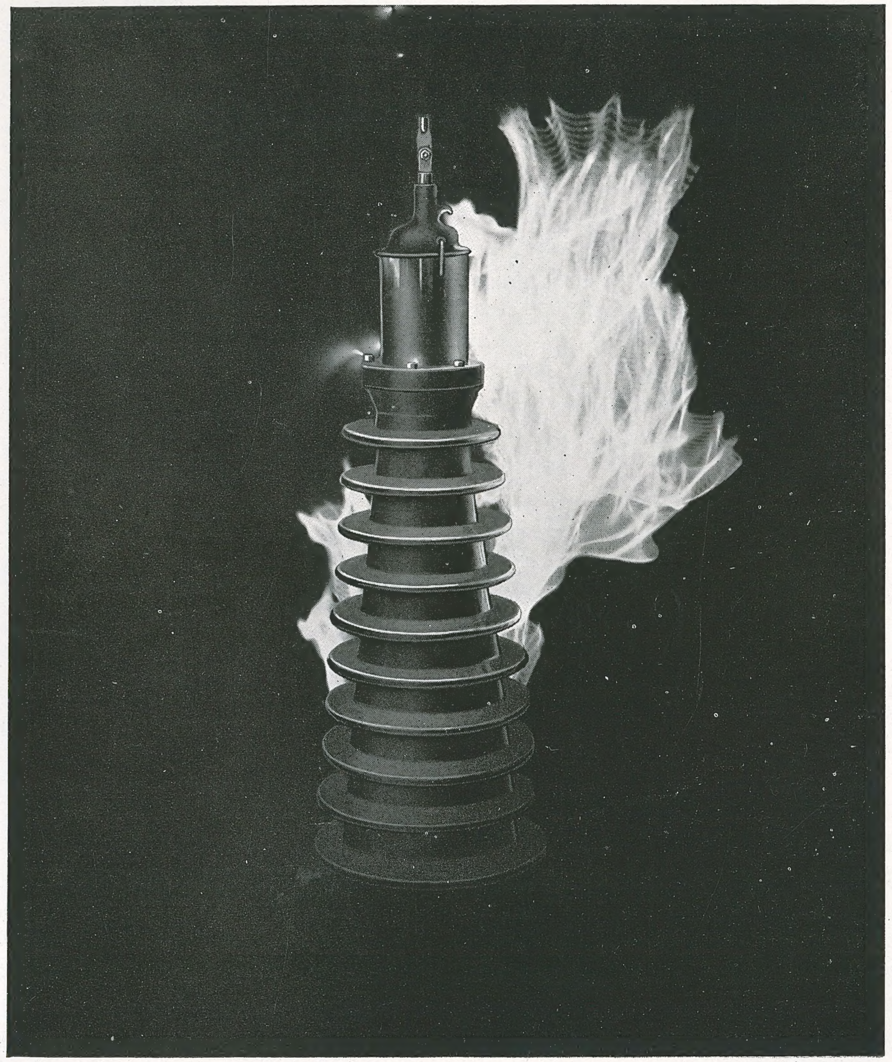


Fig. 1. DRY FLASHOVER OF F3 BUSHING AT 395,000 VOLTS

NOTE.—Data subject to change without notice.
Class 215.